Feasibility study of a microplasma high-brightness EUV source at 13.5 nm

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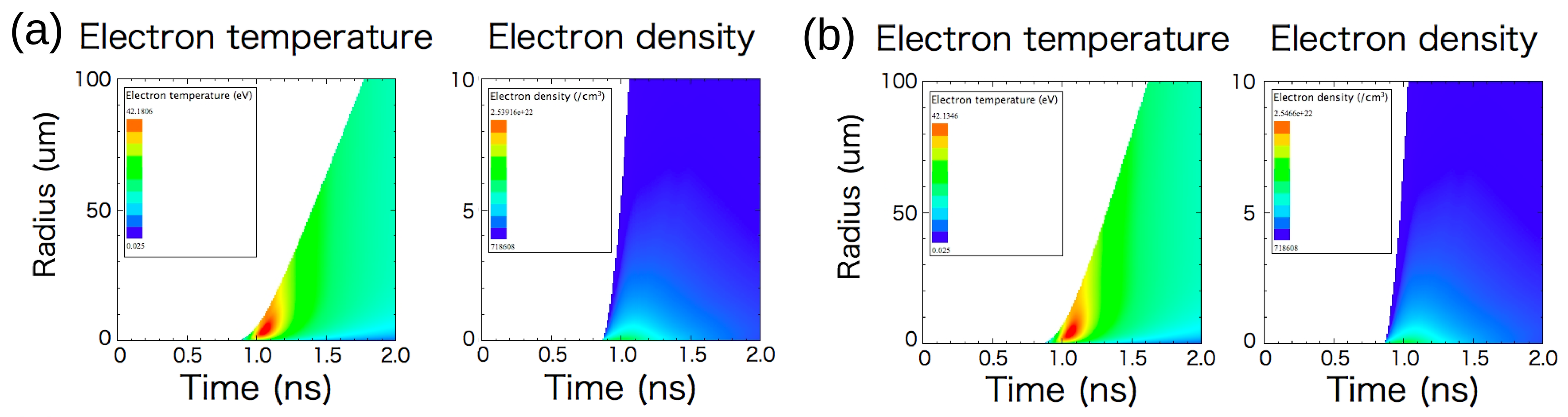
1. Introduction

We investigated the feasibility of using a high-brightness microplasma EUV source at 13.5 nm as a metrology source. Compared with the HVM case, specific requirements for metrology sources have not yet been specified. The light source needs to be stable, small with an etendue in the order of 0.03 mm^{2}sr, and high-brightness with a few watts of power. The microplasma for a metrology source should be produced to be of the order of 10-20 μm with a millijoule per pulse. We show a proof-of-principle experiment by use of a microtarget with a diameter of 10 μm with a thickness of 100 nm and the results are supported by numerical simulation.

2. Numerical evaluation for EUV emission



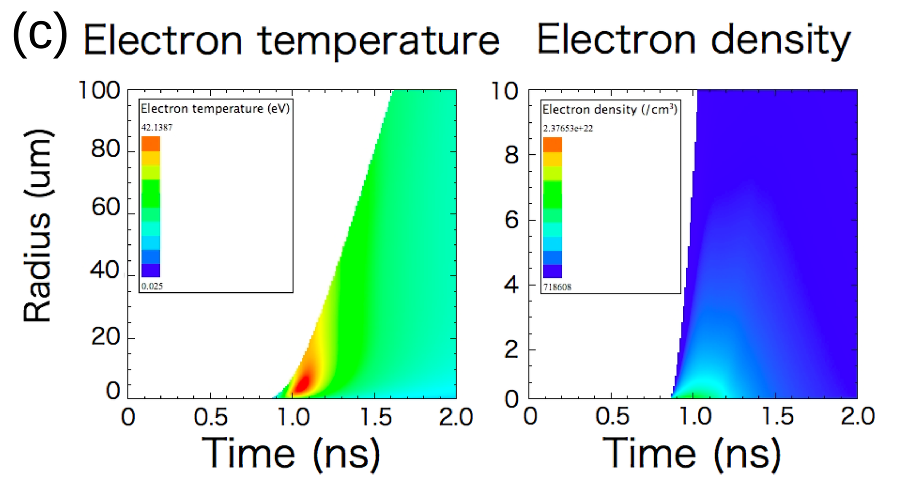


Fig. 1. Profiles of electron temperature and electron density at a laser intensity of 5 x 10^{11} W/cm^2 at different target thicknesses of **1 mm (a)**, **1 um (b)**, and **500 nm (c)**, respectively. When the target thickness thicker exceeds 500 nm, the plasma parameters are expected to be almost the same.

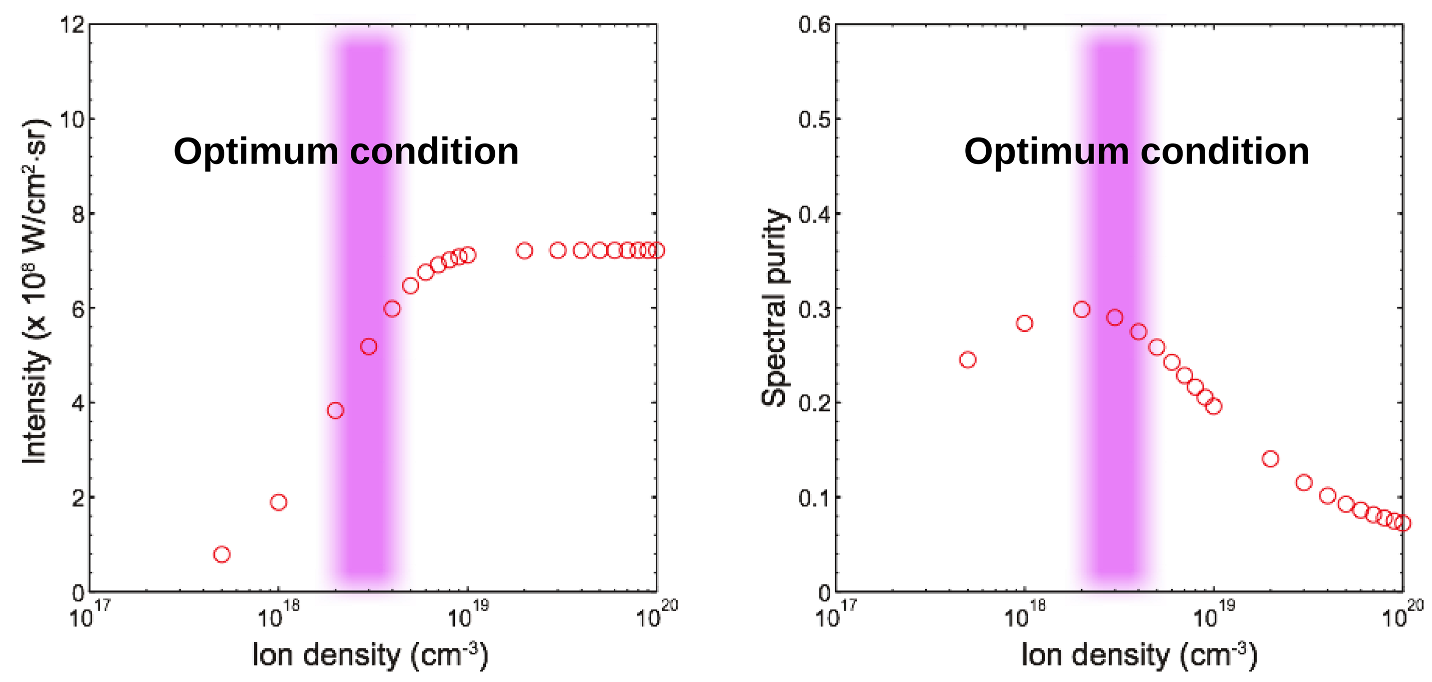


Fig. 2. Numerical evaluation of the in-band intensity (a) and spectral purity (b) as a function of the ion density at the optimum electron temperature of **35 eV**.

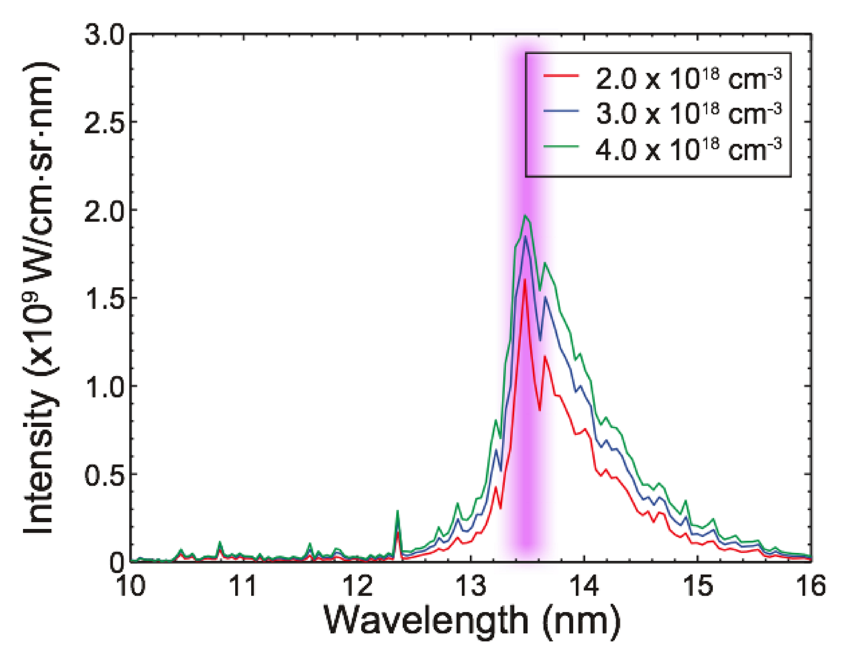


Fig. 3. Roughly evaluation of the EUV spectra at different ion densities from 2 x 10^{18} to 4 x 10^{18} cm^{-3}.

3. Magnetic field evaluation for mitigation

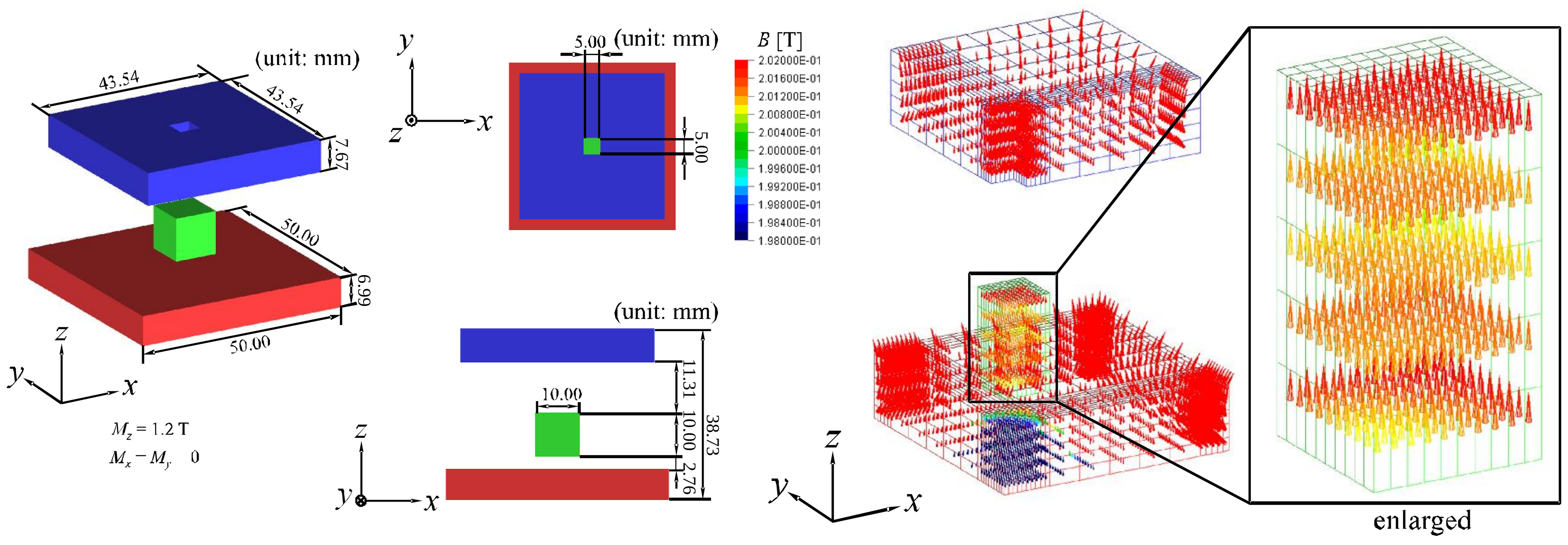


Fig. 4. (a) The radial profile of the electron density, measured at the capillary exit (blue), and obtained in MHD simulation (red). (b) Time-integrated spectrum of the visible emission from the plasma jet.

4. Preparation of volume-limited Sn targets

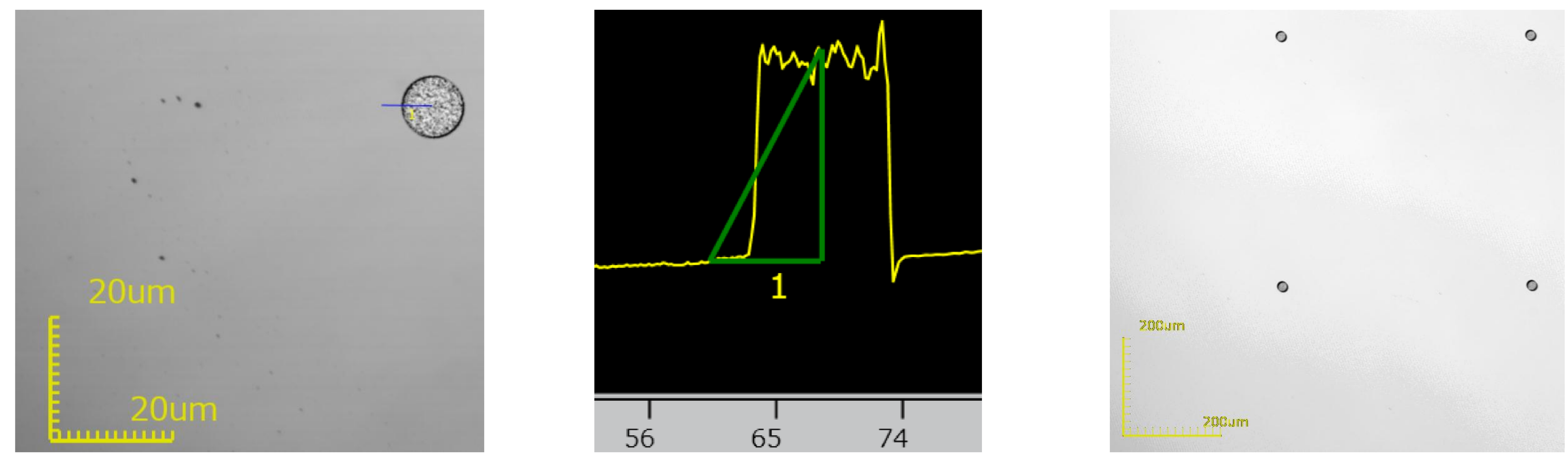


Fig. 5. Photographs of the volume-limited tin (Sn) targets with a diameter of 10 μm and the thickness of 150 nm.

5. Experimental setup & preliminary results

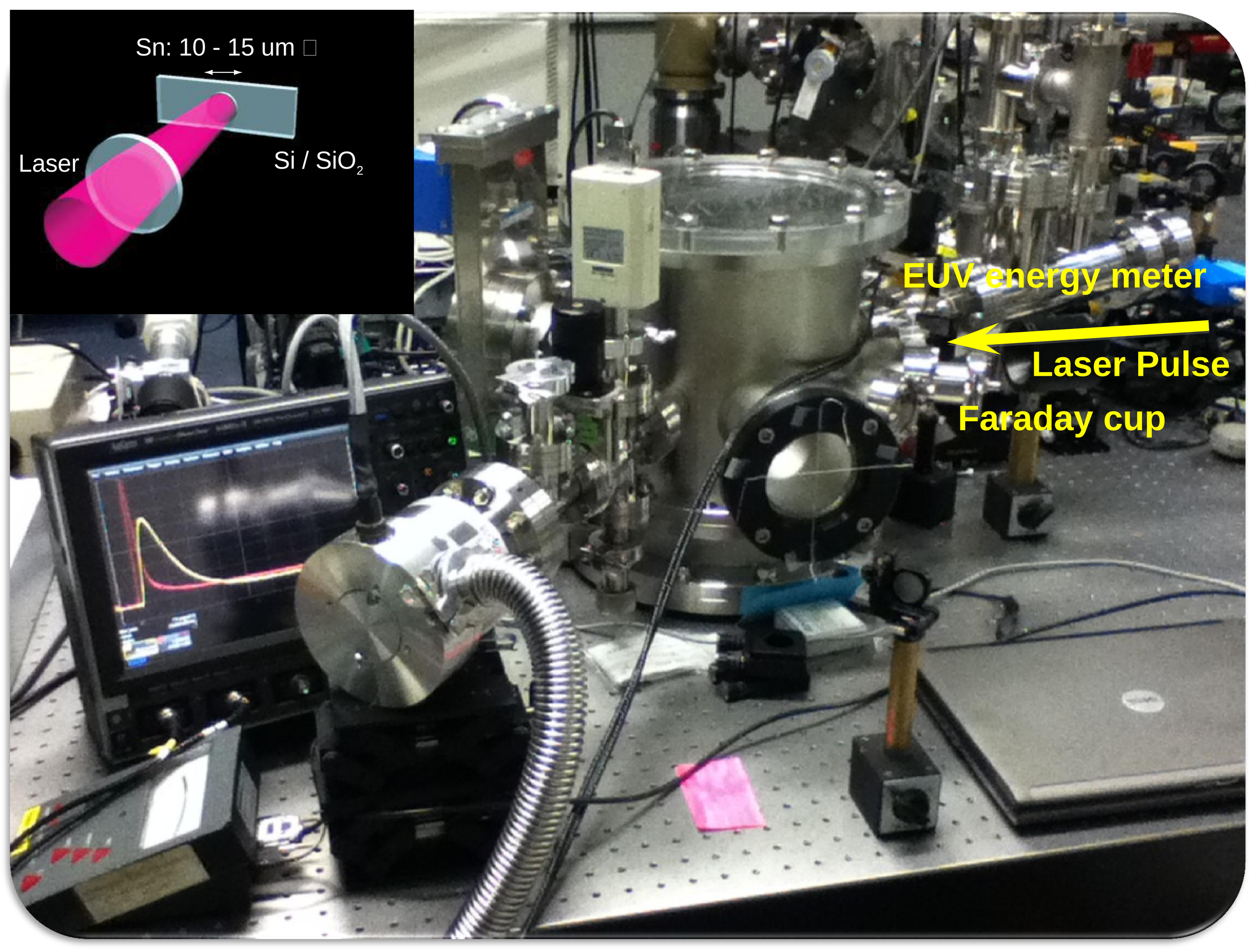


Fig. 6. Photograph of the experimental setup.

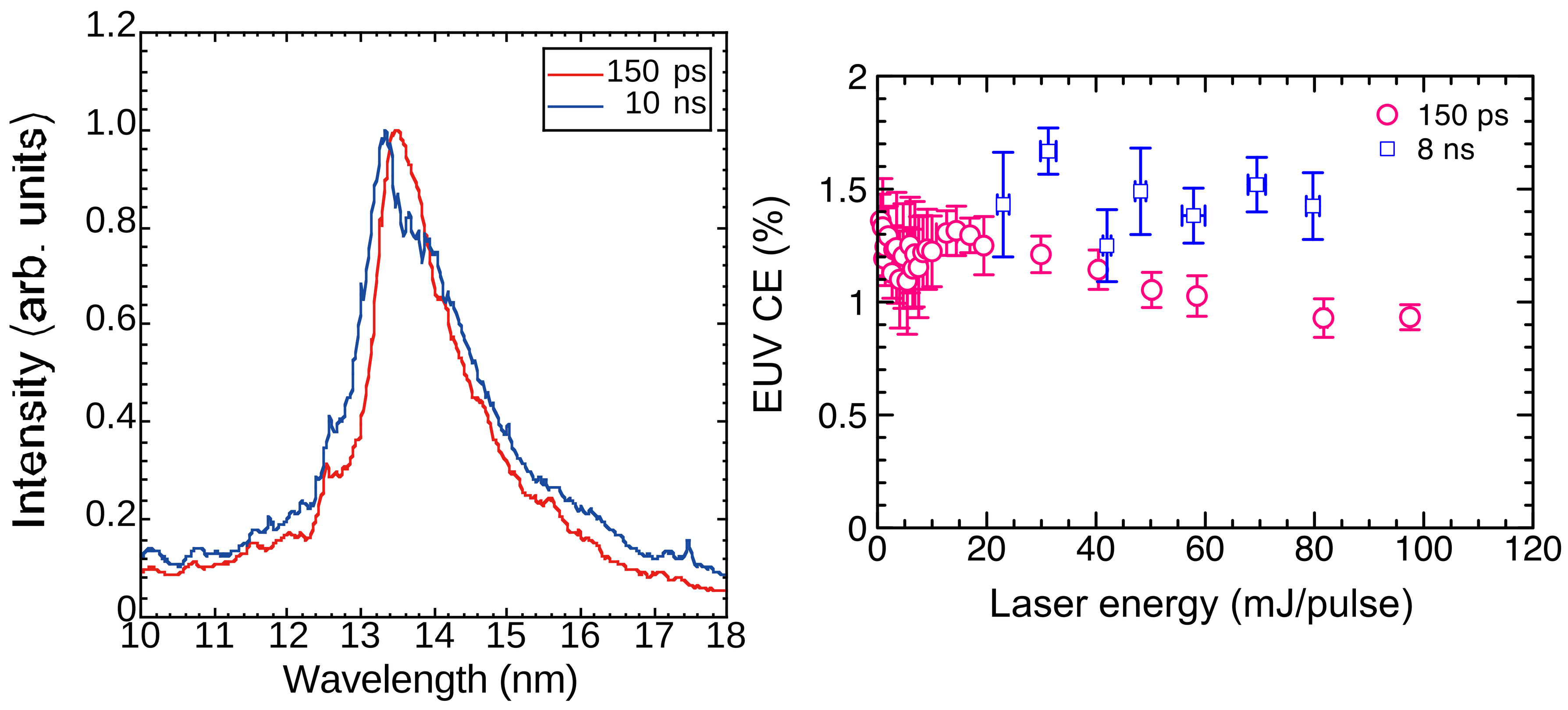


Fig. 7. ***Left:*** spectral comparison at pulse durations of 150 ps and 10 ns at a laser wavelength of 1064 nm. ***Right:*** conversion efficiency of in-band 13.5-nm emission as function of the laser energy.

6. Summary

We have investigated a 13.5-nm high brightness source for mask metrology.

- The optimum plasma parameters and expanded plasma volume, which corresponds to the source size, were evaluated. The optimum electron temperature and ion density were 35 eV and (2-4) x 10^{18} cm^{-3} respectively.
- The magnetic filed strength was calculated to be 0.2 T in the source position by use of permanent magnets with a magnetic induction of 1.2 T.
- The volume-limited targets are prepared with a diameter of 10 um and a thickness of 150 nm.
- The effect of self-absorption was small and the behavior of the EUV CE was observed.

Acknowledgements

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